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GEOPHYSICAL VARIABLES AND BEHAVIOR: XX. WEEKLY NUMBERS OF MINING ACCIDENTS AND THE WEATHER MATRIX: THE IMPORTANCE OF GEOMAGNETIC VARIATION AND BAROMETRIC PRESSURE

MICHAEL A. PERSINGER[1] AND MICHAEL NOLAN[2]

Laurentian University

Summary.—The magnitudes of the relationship between the conditions of the weekly weather matrix and the numbers of mining accidents during a one-year period were determined by multivariate analyses. Measures of means and variations in temperature, humidity, sunshine hours, windspeed, precipitation, barometric pressure, and geomagnetic activity per week were selected. The analyses were dominated by single variables. Whereas medical aid accidents tended to increase as the barometric pressure decreased, first aid accidents increased as the geomagnetic variation increased. The barometric pressure changes accommodated 16% of the variance in the numbers of medical accidents while geomagnetic variations accommodated 23% of the variance in first-aid accidents.

The weather matrix has been described as the aggregate of meteorological and geophysical stimuli to which human populations are exposed for durations of between a few hours to a few days (1). If the weather matrix can affect mood and disrupt autonomic functions (2), then a correlation between these environmental stimuli and severe consequences of behavioral disruption, e.g., accidents, should also occur. This study was designed to determine whether multivariate analyses of the weather matrix could explain substantial amounts of variance within a population of mining accidents.

Weeks were selected as cases (increments of analysis) since: (1) fixed daily analyses would not be adequate if variable latencies existed between weather changes and the frequency of accidents and (2) the persistent contributions from weekend and week-day effects in the working environment were attenuated. The total numbers of first aid and medical aid mining accidents (from below and above ground) were collected for the months between May, 1973 through May, 1974 from the safety office of a local company. The data were taken for two operations, site 1 and site 2, separated by about 50 km. The means and standard deviations for first aid and medical aid accidents per week for this 12-mo. interval were 13.2 $\pm$ 4.9 and 7.2 $\pm$ 2.9, respectively. During this time, the work force varied by about $\pm$1%.

Variables from the weather matrix were selected on the basis of previous criteria (1) and by the hypothesis that the amount of change, rather than the sustained magnitude, of weather variables contains the critical factors that pre-

[1]Department of Psychology, Sudbury, Ontario, Canada P3E 2C6.
[2]Now at the Department of Psychology, Lakehead University, Thunder Bay, Ontario.

cipitate discrete human behaviors, such as accidents. The average measures involved the weekly means of daily average: temperature (MTEMP), relative humidity (MHUMI), windspeed (AVEWI), precipitation (TOPRE), barometric pressure (MBARO) and Ap indices (a measure of geomagnetic activity), and total numbers of sunshine hours (SUNHR). Intraweek variation measures included the weekly mean of the maximum daily change in barometric pressure (DBARO) and the standard deviation of the week for the daily mean barometric pressure (MBAROSD), daily Ap indices (APSD), and mean temperature (TEMPSD). Large APSD values indicate weeks with brief geomagnetic storms whose intensities were much higher than those of other days of the week.

The means and standard deviations for these variables over the total interval were MTEMP (38.7 $\pm$ 22.7° F), TEMPSD (5.9 $\pm$ .9° F), MHUMI (72.2 $\pm$ 8.9%), AVEWI (11.9 $\pm$ 2.0 mph), SUNHR (5.5 $\pm$ 2.5), TOPRE (0.96 $\pm$ 0.77 inches), MBARO (975.8 $\pm$ 4.0 mb), MBAROSD (6.1 $\pm$ 2.8 mb), DBARO (6.5 $\pm$ 2.9 mb), Ap index (16.2 $\pm$ 6.2), and APSD (9.8 $\pm$ 5.7). Interweek variation measures were calculated. They were: the ratio of sunshine hours for each week from the previous week (SUNRA), the ratio of Ap means for each week from the previous week (APRA) and the ratio of barometric pressure for each week from the previous week (BARORA). To determine whether or not first aid and medical aid accidents were coincident or lagged phenomena, both types of accidents were lagged from 1 to 3 weeks.

For comparison and to determine internal replication, the 52-wk. period was divided into two segments (June, 1973 through November, 1973; December, 1973 through May, 1974). Separate multiple regression analyses (REGRESSION) were completed for each of these segments and for each type of accident (first aid versus medical aid). All the meteorological and geophysical variables from the same week of the accidents were allowed to enter the analyses. They were completed using SPSS software on a DEC2020 System Computer. Except for MTEMP, all variables did not display temporal artifacts as determined by correlating each component of the weather matrix with the case number (weeks) over the duration of either segment.

There was no consistent correlation between the numbers of medical and first aid accidents within the same week for the two segments. Whereas the correlation was -0.41 ($df = 1/24$, $p < .01$) for the first segment, the correlation was not statistically significant (0.21) for the second. On the other hand, there was a consistent tendency for an increase in first aid accidents to occur two weeks before an increase in medical aid events; the correlation coefficients ($p \leq .05$) for the two segments were 0.35 and 0.36, respectively. Box-Jenkins analysis for autocorrelations indicated no statistically significant ($p > .05$) periodicities in either the medical aid or first aid accidents. Sim-

ilarly, there were no temporal artifacts (change in the numbers of accidents over sequences of weeks) for either period (r-values < 0.20).

The results of the contemporary analyses for the two segments were similar for each type of accident. Although all geophysical and weather variables were allowed to enter, each category was dominated by only one major variable. Total numbers of medical aid accidents per week increased as the mean weekly barometric pressure decreased in both Segment 1 (—0.31) and Segment 2 (—0.51); the correlation was —0.40 ($p < .01$) for the entire year ($n = 52$ wk.). Zero-order correlations between MBARO and precipitation, sunshine hours, and humidity were not statistically significant ($p > .05$).

First-aid accidents were persistently correlated with the weekly geomagnetic perturbation measure (APSD). Total first-aid accidents increased as the variation in the day-to-day Ap index within a week increased for both the first (0.37) and second (0.57) segments. The correlation was evident over the entire year (0.47, $df = 1/49$, $p < .001$) and was consistent within the two mining loci (0.41 and 0.34, both dfs $= 1/49$, $p < .01$). Scattergrams indicated that the significant correlations were not based on outliers. Interestingly, the correlation ($r = 0.41$) for the first-aid accidents between the two mining sites was significant ($p < .05$) for the second segment only. However, partial correlation analyses reduced this value to $r = 0.22$ (ns) when the variance shared with APSD was removed.

The reduction in the strength of the relationship between the numbers of first aid accidents in the two sites strongly indicates that a third factor: geomagnetic variation (or some variable or groups of variables associated with this measure), affected these accidents in each site, separately. Zero-order correlations indicated no statistically significant correlations ($r < 0.20$) between APSD and other components of the weather matrix except for the average Ap index measure (0.54). Factor analysis (Factor; PA2 method from SPSS, for the year) demonstrated that both geomagnetic variables loaded on a different factor (eigenvalue = 1.69; 17% of the variance explained) than all the other weather variables. After Varimax rotation, one factor (2.72; 31% of the variance) was loaded by (correlations in parentheses) TEMPSD (0.73), SUNHR (—0.42), AVEWI (0.54), MBAROSD (0.65), and DBARO (0.85) while the second factor (1.84; 19% of the variance) was loaded by MHUMI (0.98), SUNHR (—0.62), and TOPRE (0.49).

These results are commensurate with previous studies. First-aid accidents are presumably influenced quite substantially by psychological contingencies and mood; previous research indicates the persistent appearance of geomagnetic factors in motivation-related accidents (1) and mood (2). Medical accidents, on the other hand, are associated with more severe body trauma and appear to involve a different set of psychosocial or machinery-related variables. Measures

of barometric pressure that are not contaminated by obvious artifacts (rainfall) have been associated with these types of accidents (1).

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